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Comparison of Phytochemicals and Antioxidant Properties of Different Fruit Parts of Selected *Artocarpus* Species from Sabah, Malaysia

(Perbandingan Ciri Fitokimia dan Antioksida pada Bahagian Buah yang Berbeza bagi Spesies *Artocarpus* Terpilih dari Sabah, Malaysia)

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ABSTRACT

The purpose of this study is to investigate and compare the phytochemical contents and antioxidant activity of 80% methanol extracts of three selected fruits of Artocarpus *species namely,* Artocarpus odoratissimus *(tarap),* Artocarpus kemando *(pudu) and* Artocarpus integer *(cempedak). The total phenolic, total flavonoid and total carotenoid contents of different parts of the fruits (peel, flesh and seed) were analyzed spectrophotometrically. The antioxidant properties were assessed by DPPH, FRAP and ABTS method. The total phenolic content of all parts of the fruits ranging from 3.53 to 42.38 mg GAE/g of dry sample. The total flavonoid was in the range of 0.82 to 36.78 mg CE/g of dry sample whereas the total carotenoid ranging from 0.67 to 3.30 mg ß-carotene/g of dry sample. The peel and seed displayed higher phytochemical contents (as compared with the flesh) and were found to be efficient radical scavengers and reducing agents. Total phenolic and total flavonoid contents were significantly correlated with the antioxidant activities. However, the total carotenoid was weakly correlated with the antioxidant activities. Due to the findings of this research, it is observed that the phytochemical compounds are the major contributor to the antioxidant activities.* A. odoratissimus *has the potential to be used as antioxidant agents due to high phytochemical contents and high antioxidant activity for all tested methods.*

Keywords: Antioxidant activity; Artocarpus *species*; *phytochemical contents*

ABSTRAK

Tujuan penyelidikan ini dijalankan adalah untuk mengkaji dan membuat perbandingan kandungan fitokimia dan aktiviti antioksida pada ekstrak metanol 80% bagi tiga spesies buah Artocarpus *yang terpilih iaitu* Artocarpus odoratissimus *(tarap),* Artocarpus kemando *(pudu) dan* Artocarpus integer *(cempedak). Jumlah kandungan fenolik, flavonoid dan karotenoid bahagian buah (isi, kulit dan biji) telah dianalisis dengan menggunakan spektrofotometri. Aktiviti antioksida ditentukan melalui kaedah DPPH, FRAP dan ABTS. Kesemua bahagian sampel menunjukkan jumlah kandungan fenolik berjulat daripada 3.53 hingga 42.38 mg GAE/g sampel kering. Jumlah kandungan flavonoid pula berjulat daripada 0.82 hingga 36.78 mg CE/g sampel kering manakala jumlah kandungan karotenoid berjulat dari 0.67 hingga 3.30 mg ß-karotene/g sampel kering. Bahagian kulit dan biji menunjukkan kandungan fitokimia yang tinggi (berbanding isi) dan merupakan penghapus radikal dan agen penurunan yang cekap. Jumlah kandungan fenolik dan flavonoid berkorelasi secara signifikan dengan aktiviti antioksida. Walau bagaimanapun, jumlah kandungan karotenoid berkorelasi secara lemah dengan aktiviti antioksida. Berdasarkan hasil kajian, kompaun fitokimia merupakan penyumbang utama kepada aktiviti antioksida.* A. odoratissimus *berpotensi untuk dijadikan agen antioksida disebabkan oleh kandungan fitokimia dan aktiviti antioksida yang tinggi terhadap semua kaedah yang dijalankan.*

Kata kunci: Aktiviti antioksida; *kandungan fitokimia*; *spesies* Artocarpus

INTRODUCTION

Polyphenols phytochemicals are non-nutrient compound of plants that have been suggested to prevent and treat cardiovascular diseases, cancers, osteoporosis, neurodegenerative diseases and diabetes mellitus (Abu Bakar et al. 2010). Phenolic acids and flavonoids which are most abundant in human diets are the examples of main classes of polyphenols. Plant-based products such as fruits, vegetables and grains contain high phytochemical contents which may act as natural antioxidants (Liu 2004). Secondary metabolites of plants involving phenolics and carotenoids play an important role in reproduction, growth as well as protection against pathogens and parasites.

The state of Sabah is known to be rich in biodiversity of tropical and underutilized fruits. Wild fruits are commonly found in the tropical rain forest and highlands. Some of the fruits under the genus of *Artocarpus* are endemic to Sabah. The trees of the genus of *Artocarpus* are sensitive towards changes in soil acidity and temperature of the surroundings. According to Hashim et al. (2011), almost all plant parts of some members of *Artocarpus* genus have been reported associated with the prevention

and treatment of various diseases such as liver cirrhosis, high blood pressure and diabetes. This therapeutic value might be due to their phytochemical contents (Jagtap & Bapat 2010).

Artocarpus odoratissimus, *Artocarpus integer* and *Artocarpus kemando* belong to the family of Moraceae. *A. odoratissimus* is found to be endemic to Borneo Island. This species has been introduced in the Philippines (Soepadmo & Saw 2000). It is a very popular fruit in Sabah and it is locally known in Sabah, Malaysia as 'tarap' (Abu Bakar et al. 2009). According to Ee et al. (2010), *A. odoratissimus* consist of artosimmin, a phytochemical compound derived from flavonoid group which displayed cytotoxic activity against breast cancer cell and promyelocytic leukemia.

A. integer is locally known in Malaysia as 'cempedak'. This fruit is originally from Sumatra, Borneo Island, Sulawesi, Maluku and the west area of New Guinea. It has been widely planted in Thailand, Sumatra, Peninsular Malaysia, Indonesia and Myanmar. In Indonesia, the root of *A. integer* plant has been used as traditional medicine to treat malaria and diarrhea (Syah et al. 2006). According to Hakim et al. (2005), the extract of woody stem of *A. integer* displayed cytotoxic activity against leukemia cancer cell. On the other hand, *A. kemando* can be found in Sumatra, Singapore, peninsular Malaysia and Borneo Island (Soepadmo & Saw 2000). In Sabah, this fruit is locally known as 'pudu' by Dusun people whereas in Sarawak, *A. kemando* has a different local name according to different ethnics (Soepadmo & Saw 2000). This fruit has been listed as endangered plant species (Chong et al. 2009). The chemical compounds namely, artosimmin, artomandin and cycloartobiloxanthone extracted from *A. kemando* displayed antioxidant activity (Ee et al. 2012).

This study was conducted to compare the phytochemicals and antioxidant potential of different fruit parts of selected *Artocarpus* species found in Sabah, Malaysian Borneo.

Materials and Methods

Plant materials and sample preparation

The fruits of *A. odoratissimus*, *A. integer* and *A. kemando* were collected from Sabah, Malaysia. Voucher specimens were identified and deposited into BORNEENSIS, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Malaysia. The fruits were cleaned, weighed and separated into flesh, peel and seed. Fresh samples were sized into 1 cm^3 dimensions. Small cut pieces were freeze-dried and the freeze-dried samples were ground into fine powder using an electric blender (Philips Model: RI2008/31). The samples were kept in air tight container and stored in a freezer at -20°C until further analysis.

Extraction

Samples were weighed (0.1 g) and extracted for 2 h with 10 mL of 80% methanol at room temperature on an orbital shaker set at 200 rpm (Velioglu et al. 1998). The mixture was then filtered using filter paper and was used for the determination of total phenolic contents, total flavonoid contents, total carotenoid content and antioxidant activities.

Determination of total phenolic content

Total phenolic content was determined using Folin-Ciocalteu reagent as adapted from Velioglu et al. (1998) with slight modifications. 300 microliter of extract was mixed with 2250 µL of Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water), vortex for 15 s and allowed to stand at room temperature for 5 min. After that, the mixture was added with 2250 µL of sodium bicarbonate (60 g/L) solution. After 90 min at room temperature, absorbance was measured at 725 nm using spectrophotometer. Standards of gallic acid in the concentration ranging from 0 to 100 µg/mL were run with the test samples, from which a standard curve was plotted. The results were expressed as mg gallic acid equivalent in 1 g of dried sample (mg GAE/g).

Determination of total flavonoid content

Total flavonoid was determined according to a colorimetric method adapted by Zhishen et al. (1999). Briefly, 1 mL of extract was mixed with 4 mL of distilled water and 0.3 mL of 5% sodium nitrite ($NaNO_2$) solution. The mixture was then added with 0.6 mL of 10% aluminium chloride hexahydrate ($AlCl_3.6H_2O$) and allowed to stand for 6 min before 2 mL of 1M sodium hydroxide (NaOH) was added to the mixture. The mixture was mixed well using vortex. Absorbance was measured immediately at 510 nm using spectrophotometer. Standards of catechin in the concentration ranging from 20 to 100 µg/mL were run with the test samples, from which a standard curve was plotted. The results were expressed as mg catechin equivalent in 1 g of dried sample (mg CE/g).

Determination of total carotenoid content

Total carotenoid content of sample extracts was measured using method described by Hess et al. (1991) with slight modification. An aliquot (600 µL) of sample extract was added with 600 µL of distilled water and 1200 µL methanol. The mixture was mixed with 2400 µL of hexane. The mixture was then centrifuged at 2000 rpm for 5 min. Absorbance was read spectrophotometrically at 350 nm. The results were expressed as mg of ß-carotene per g of dried sample (mg ßC/g).

DPPH radical scavenging activity

The scavenging activity of the extract was measured by using 2,2-diphenyl-1-pycrylhydrazyl (DPPH) as a free radical model, a method adapted from Mensor et al. (2001). An aliquot (1 mL) of 0.3 mM methanol solution of 2,2-diphenyl-1-pycrylhydrazyl (DPPH) was added into 2.5 mL sample or standards. The solution was shaken

vigorously and left to stand at room temperature for 30 min in the dark. The mixture was measured at 518 nm by using spectrophotometer. The percentage of antioxidant activity (AA) was calculated:

$$AA\% = 100 - \left[\frac{(Abs\ sample - Abs\ empty\ sample)}{Abs\ control}\right] \times 100,$$

where Abs is the absorbance; empty sample = 1 mL 80% methanol + 2.5 mL extract; and control sample = 1 mL 0.3 mM DPPH + 2.5 mL 80% methanol.

FRAP (FERRIC REDUCING/ANTIOXIDANT POWER) ASSAY

This procedure was carried out according to Benzie and Strain (1996) with slight modifications. The working FRAP reagent was produced by mixing 300 mM acetate buffer (pH3.6), 10 mM 2,4,6-tripyridyl-s-triazine (TPTZ) solution and 20 mM $FeCl_3.6H_2O$ in a 10:1:1 ratio prior to use in water bath at 37°C. A total of 3.0 ml FRAP reagent was added to a test tube and a blank reading was taken spectrophotometrically at 593 nm. A total of 100 µL of selected plant extracts and 300 µL of distilled water were added to the test tube. After addition of the sample to the FRAP reagent, a second reading at 593 nm was performed after 4 min. The changes in absorbance after 4 min from initial blank reading were compared with standard curve ($FeSO_4$). A standard of known Fe (II) concentrations were run using several concentrations in the range of 200 to 1000 µg/mL. A standard curve was plotted. The final result was expressed as the concentration of antioxidant having a ferric reducing ability in 1 g of dry sample (µM/g).

ABTS RADICAL CATION DECOLORIZATION

ABTS free radical decolorization assay was conducted according to method described by Re et al. (1999) with slight modifications. Working ABTS solution (7 mM) and 2.45 mM potassium persulfate ($K_2S_2O_8$) were added into a beaker. The mixture was allowed to stand for 15 h in the dark at room temperature and the mixture was then diluted with 80% methanol to obtain the absorbance of 0.7±0.02 units at 734 nm. An aliquot of 200 µL of methanolic test solution of each sample was added to 2000 µL of ABTS free radical cation solution. The mixture was vortex for 45 s. The absorbance was measured at 734 nm by using spectrophotometer. Standards of ascorbic acid in the concentration ranging from 0 to 100 µg/mL were run with the test samples, from which a standard curve was plotted. The radical scavenging activity was expressed as mg ascorbic acid equivalent antioxidant capacity in 1 g of dry sample (mg AEAC/g).

STATISTICAL ANALYSIS

All experiments were carried out in 3 replicates in 3 independent experiments. The results were expressed as mean±standard deviation (SD) using SPSS version 17.0. The data were statistically analyzed by one-way ANOVA. Pearson's correlation analysis was done to correlate the phytochemicals and antioxidant potential between samples. P-value < 0.05 was set as significant.

Results and Discussion

TOTAL PHENOLIC CONTENT

The results showed that *A. odoratissimus* peel extract contained the highest total phenolic content followed by the peel of *A. integer* (Table 1). Unlike *A. odoratissimus* and *A. integer*, the seed extract of *A. kemando* showed the highest amount of phenolic followed by peel and flesh of the sample (Table 1). The peel and seed of *A. odoratissimus* displayed higher amount of phenolic than the peel extract of *A. integer* and *A. kemando* (Table 1). For the flesh part, *A. kemando* extract showed higher total phenolic content than *A. odoratissimus* and *A. integer* (Table 1). The result of this study supported that the members of *Artocarpus* species were rich in phenolics that might contribute to high antioxidant activities (Jagtap & Bapat 2010). Phenolic contents are believed to be higher in the outer part compared to the flesh part due to self-protection from pathogens, microorganisms and predators. According to Kubola and Siriamompun (2011), the flesh of ripen fruits consist less amount of phenolics as compared to the seed part of the fruits. The concentration of phenolic increase

TABLE 1. Determination of total phenolic content in extracts of *A. odoratissimus*, *A. integer* and *A. kemando*

Sample	Parts	Total phenolic content[1] (mg/g)
A. odoratissimus	Peel	42.38±0.20[a]
A. integer	Peel	21.29±0.43[b]
A. odoratissimus	Seed	13.72±0.87[c]
A. integer	Seed	11.87±0.30[d]
A. kemando	Seed	11.67±0.55[e]
A. kemando	Peel	8.46±0.76[f]
A. kemando	Flesh	6.57±0.60[g]
A. integer	Flesh	4.40±0.20[h]
A. odoratissimus	Flesh	3.53±0.33[i]

[1]Total phenolic content was expressed as mg gallic acid equivalents in 1 g of dry sample (mg GAE/g)

as the fruits reach the maturity state because phenolics are involve in the process of seed germination (Dueñas et al. 2009). The phenolics that exist in the seed are responsible to act as antioxidants to avoid internal damage due to oxidation that occur during the germination of seed process (Andarwulan et al. 1999). There is a significant difference (p<0.05) between species and between parts of fruit in this study which is similar to the findings of a study conducted by Soong and Barlow (2004).

TOTAL FLAVONOID CONTENT

The present study showed that the peel, seed and flesh extracts of *A. odoratissimus* showed the highest flavonoid content as compared to *A. integer* and *A. kemando* (Table 2). The peel part of *A. odoratissimus* and *A. integer* showed the highest flavonoid contents than seed and flesh. However, different trend was observed for *A. kemando* where the seed extract showed the highest amount of flavonoid as compared to the peel and flesh part of the same fruit. This might be due to the presence of other flavonoid groups such as tannin, stilbenoids and lignan in the seed part. In this study, the lowest flavonoid content was showed by the flesh part of *A. integer* (Table 2). The findings of this study were almost similar to the study conducted by Abu Bakar et al. (2009) on bambangan and tarap; and Soong & Barlow (2004) on avocado, jackfruit, longan, mango and tamarind which showed that the phytochemical contents were higher in peel and seed part as compared to the edible part of the fruits. The outer part of fruits that was being exposed to the sunlight has a higher phytochemical contents due to the synthesis of flavonoid for the absorption of UV light (Heim et al. 2002; Osorio-Esquivel et al. 2011; Spitaler et al. 2006; Wang et al. 2005). Various study conducted on genus *Artocarpus* proved that phenolic and flavonoid are the most important substances in phytochemical group that displayed numerous biological activity and pharmacology properties which include antibacterial, anticancer, antiplatelet, antihelmintic, antimalarial, anti-inflammatory and antioxidants (Jagtap & Bapat 2010). For total flavonoid, there is a significant difference (p<0.05) between species and between parts of fruits.

TOTAL CAROTENOID CONTENT

Basically, carotenoid gives yellow, orange or red colour to plants. The result showed that carotenoid only present in considerable amount in the brighter colour of the peel part of *A. kemando* followed by peel extracts of *A. integer* and *A. odoratissimus*. Only a small amount of carotenoid was detected in the seed part of *A. odoratissimus* (Table 3). A study by Remorini et al. (2008) on peach reported that the carotenoid contents were higher in the peel part as compared to the flesh is almost similar to the result of

TABLE 2. Determination of total flavonoid content in extracts of *A. odoratissimus*, *A. integer* and *A. kemando*

Sample	Parts	Total flavonoid content[2] (mg/g)
A. odoratissimus	Peel	36.78±0.28[a]
A. integer	Peel	17.45±0.46[b]
A. odoratissimus	Seed	10.18±0.81[c]
A. kemando	Seed	8.98±0.24[d]
A. kemando	Peel	5.43±0.33[e]
A. integer	Seed	3.58±0.11[f]
A. odoratissimus	Flesh	1.23±0.09[g]
A. kemando	Flesh	0.94±0.03[h]
A. integer	Flesh	0.82±0.06[i]

[2]Total flavonoid content was expressed as mg catechin equivalents in 1 g of dry sample (mg CE/g)

TABLE 3. Determination of total carotenoid content in extracts of *A. odoratissimus*, *A. integer* and *A. kemando*

Sample	Parts	Total carotenoid content[3] (mg/g)
A. kemando	Peel	3.30±0.48[a]
A. integer	Peel	1.17±0.05[b]
A. integer	Flesh	1.09±0.03[b]
A. odoratissimus	Peel	0.86±0.04[c]
A. kemando	Flesh	0.85±0.20[c]
A. odoratissimus	Flesh	0.79±0.23[c]
A. integer	Seed	0.72±0.01[c]
A. kemando	Seed	0.71±0.07[c]
A. odoratissimus	Seed	0.67±0.14[c]

[3]Total carotenoid content was expressed as mg ß-carotene equivalents in 1 g of dry sample (mg ßC/g)

this study. The presence of carotenoid in peel part is for protection against excessive light (Ladislav et al. 2005) where the light will be absorbed and converted into chlorophyll in terms of energy (Howitt & Pogson 2006). Carotenoid that present in small amount in the flesh part of *Artocarpus* fruits is responsible for the production of abscisic acid to control germination of seed and seed dormancy as well as for the protection of seed membrane from lipid oxidation (Howitt & Pogson 2006). Due to the low level of carotenoid detected, the analysis of colour was not further examined in this study. For carotenoid content, there is no significant difference between seed and flesh parts of the fruits.

DPPH FREE-RADICAL SCAVENGING ACTIVITY

DPPH is a method used to measure the ability of extracts to scavenge free radicals through the conversion of DPPH into a stable DPPH-H form after accepting electron or hydrogen radical. Antioxidant in sample extracts generated pale yellow colour from purple due to the power of hydrogen donating ability. The result showed that the peel and seed part of *A. odoratissimus* as well as peel part of *A. integer* displayed higher scavenging activity than ascorbic acid (Figures 1 & 2). At the concentration of 50 µg/mL, *A. odoratissimus* has reached the optimum level of free radical scavenging activity (Figure 1). Among all samples, the flesh part of *A. integer* displayed the lowest scavenging activity as at the concentration of 100 µg/mL, the scavenging activity is still lower than 50% (Figure 2). All parts of *A. kemando* showed lower free radical scavenging activity than ascorbic acid except for the seed part (Figure 3). For the flesh part, all extracts do not display scavenging activity even at the concentration of 100 µg/mL, according to Abu Bakar et al. (2009), the seed of this fruit displayed antioxidant activity twice higher than the flesh of the fruit.

FRAP FERRIC REDUCING/ANTIOXIDANT POWER

FRAP is a method used to measure the ability of phytochemicals to reduce ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}) through electron donation. Apart from simple and easy to perform, through this method, both alcohol and aqueous extracts can be used. In this study, there is a significant difference ($p<0.05$) between species and between parts of fruit. The reducing ability of peel and seed extracts of *A. odoratissimus* and *A. integer* is higher than flesh part (Table 4). High phenolic contents in peel and seed gives higher ability to donate electron (Rice-Evans et al. 1997). Among all extracts, the highest reducing ability was displayed by the peel of *A. odoratissimus* and the lowest reducing ability was shown by the flesh part of *A. integer* (Table 4).

ABTS RADICAL CATION DECOLORIZATION

ABTS is a method that measure the ability of antioxidants to scavenge ABTS$^{\cdot+}$ radical through the donation of hydrogen molecule. This method was chosen because it is not influence by the colour of plants that can affect the absorbance value of the sample extracts. Based on the result, the same trend was observed except for the seed

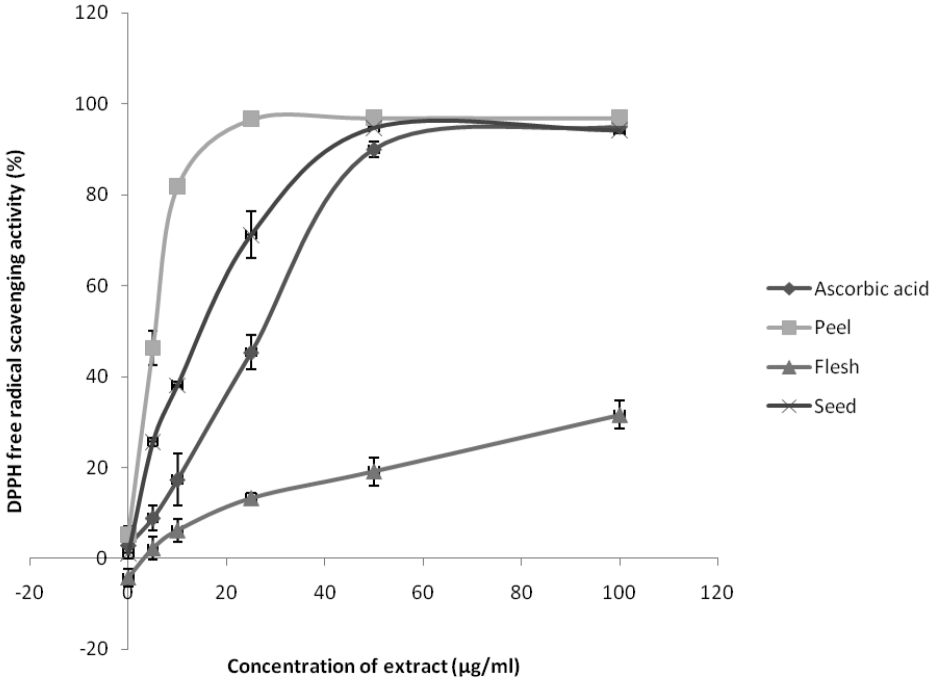

FIGURE 1. The scavenging activity of 80% methanol extracts of peel, seed and flesh part of *A. odoratissimus* assayed by DPPH free-radical scavenging method. Values are presented as mean±SD (n=3)

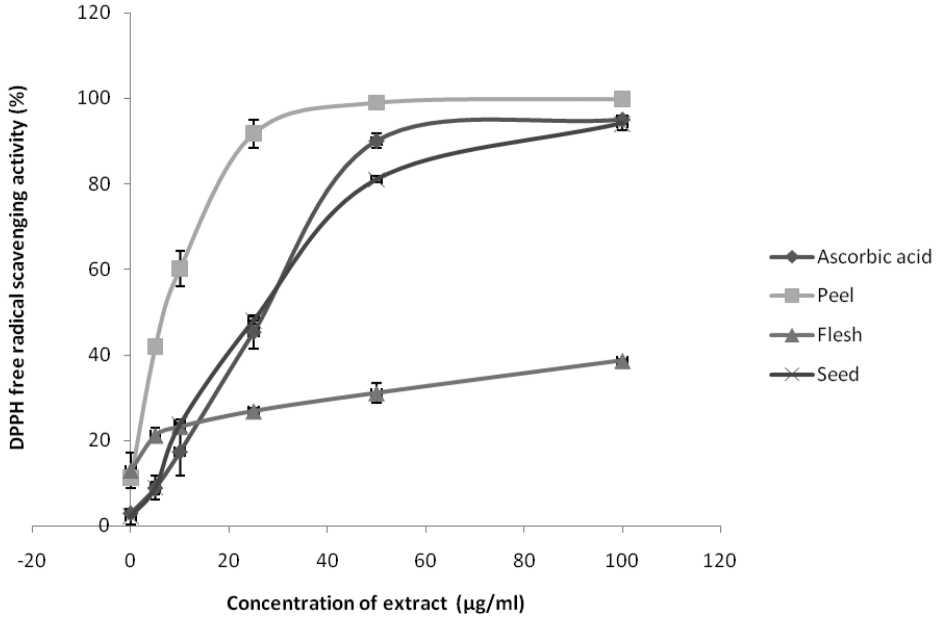

FIGURE 2. The scavenging activity of 80% methanol extracts of peel, seed and flesh part of *A. integer* assayed by DPPH free-radical scavenging method. Values are presented as mean±SD (n=3)

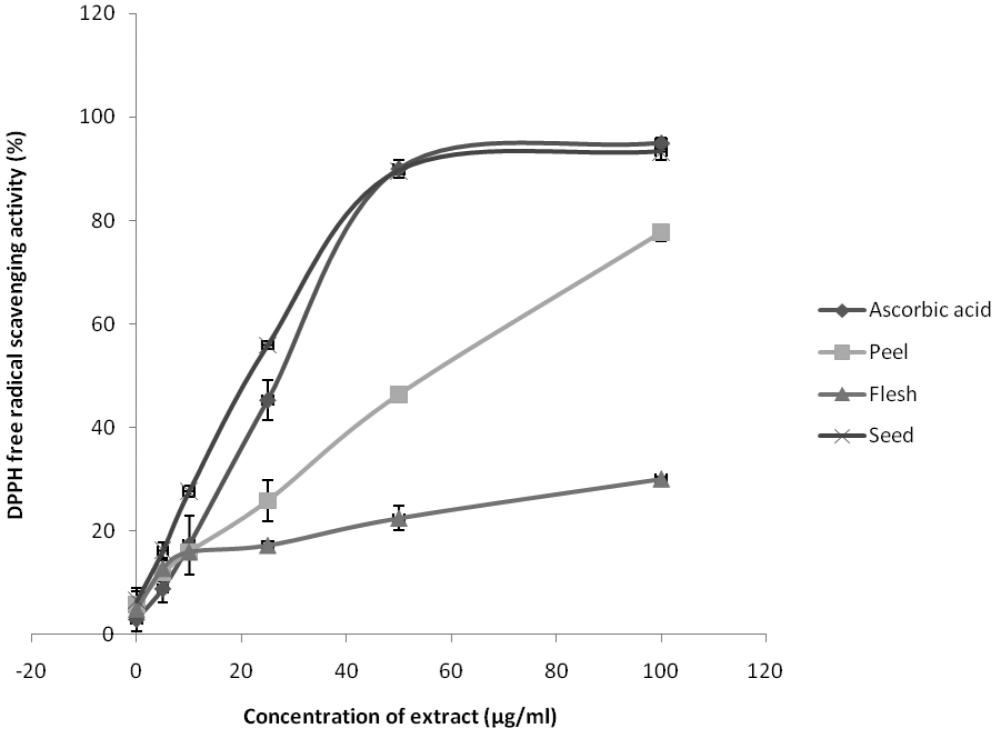

FIGURE 3. The scavenging activity of 80% methanol extracts of peel, seed and flesh part of *A. kemando* assayed by DPPH free-radical scavenging method. Values are presented as mean±SD (n=3)

part. The highest scavenging activity was displayed by the peel part of *A. odoratissimus* followed by the seed part of *A. kemando* (Table 5). Flesh part of all species displayed lower scavenging activity than peel and seed extracts (Table 5). In this study, the antioxidant activity between species and parts was significantly different (p<0.05). Scavenging activity was influenced by phenolic and flavonoid contents in each species (Abu Bakar et al. 2009; Heim et al. 2002).

TABLE 4. Antioxidant properties of extracts of *A. odoratissimus*, *A. integer* and *A. kemando*, assessed by FRAP assay

Sample	Parts	FRAP assay[1] (μM/g)
A. odoratissimus	Peel	378.93±20.25[a]
A. integer	Peel	218.91±11.36[b]
A. integer	Seed	76.58±6.63[c]
A. odoratissimus	Seed	68.06±2.93[d]
A. kemando	Seed	61.45±5.34[e]
A. kemando	Peel	56.63±2.89[f]
A. odoratissimus	Flesh	17.92±0.74[g]
A. kemando	Flesh	15.73±0.42[h]
A. integer	Flesh	13.59±0.64[i]

Values are presented as mean ± SD (n=3) which, with different letters (within column), are significantly different at p<0.05
[1]FRAP was expressed as μM ferric reduction to ferrous in 1 g of dry sample

TABLE 5. Antioxidant properties of extracts of *A. odoratissimus*, *A. integer* and *A. kemando*, assessed by ABTS assay

Sample	Parts	ABTS assay[2] (mg/g)
A. odoratissimus	Peel	26.11±0.44[a]
A. kemando	Seed	16.31±0.32[h]
A. integer	Peel	11.93±0.09[c]
A. integer	Seed	7.71±0.34[d]
A. odoratissimus	Seed	7.61±0.24[e]
A. kemando	Peel	5.73±0.08[f]
A. odoratissimus	Flesh	5.34±0.22[g]
A. kemando	Flesh	3.97±0.15[h]
A. integer	Flesh	3.97±0.08[i]

Values are presented as mean ± SD (n=3) which, with different letters (within column), are significantly different at p<0.05
[2]ABTS free radical scavenging activity was expressed as mg ascorbic acid equivalent antioxidant capacity (AEAC) in 1 g of dry sample

RELATIONSHIP BETWEEN PHYTOCHEMICALS AND ANTIOXIDANTS

Phenolic and flavonoid are phytochemicals that might contribute to the antioxidant activity in seed and flesh part of *A. odoratissimus*, *A. integer* and *A. kemando* while the carotenoid might become the major contribution to the antioxidant activity in peel part of the fruits. Correlation analysis has been performed to investigate the relationship between the phytochemical contents and the antioxidant activities in peel, seed and flesh extracts of *A. odoratissimus*, *A. integer* and *A. kemando*.

For FRAP assay, the phenolic and flavonoid showed a strong positive correlation with r=0.983 and r=0.977, respectively (Tables 6 & 7). ABTS assay also displayed strong positive correlation with the phenolic and flavonoid contents with the values of r=0.907 and r=0.920, respectively (Tables 6 & 7). For DPPH assay, carotenoid showed a positive correlation with r=0.027 whereas the phenolic and flavonoid showed a positive correlation with the values of r=0.628 and r=0.616, respectively (Table 8). For the correlation between antioxidant assays, FRAP assay showed a positive correlation with ABTS and DPPH assay

TABLE 6. Correlation analysis between phenolic contents and antioxidant activities

		Phenolic	FRAP	ABTS	DPPH
Fenolik	Pearson Correlation	1	.983**	.907**	.628*
	Sig. (1-tailed)		.000	.000	.035
	N	9	9	9	9
FRAP	Pearson Correlation	.983**		.874**	.601*
	Sig. (1-tailed)	.000	1	.001	.043
	N	9	9	9	9
ABTS	Pearson Correlation	.907**	.874**	1	.624*
	Sig. (1-tailed)	.000	.001		.036
	N	9	9	9	9
DPPH	Pearson Correlation	.628*	.601*	.624*	1
	Sig. (1-tailed)	.035	.043	.036	
	N	9	9	9	9

**Correlation is significant at the 0.01 level (1-tailed)
*Correlation is significant at the 0.05 level (1-tailed)

TABLE 7. Correlation analysis between flavonoid contents and antioxidant activities

		Flavonoid	FRAP	ABTS	DPPH
Flavonoid	Pearson Correlation	1	.977**	.920**	.616*
	Sig. (1-tailed)		.000	.000	.039
	N	9	9	9	9
FRAP	Pearson Correlation	.977**	1	.874**	.601*
	Sig. (1-tailed)	.000		.001	.043
	N	9	9	9	9
ABTS	Pearson Correlation	.920**	.874**	1	.624*
	Sig. (1-tailed)	.000	.001		.036
	N	9	9	9	9
DPPH	Pearson Correlation	.616*	.601*	.624*	1
	Sig. (1-tailed)	.039	.043	.036	
	N	9	9	9	9

**Correlation is significant at the 0.01 level (1-tailed)
*Correlation is significant at the 0.05 level (1-tailed)

TABLE 8. Correlation analysis between carotenoid contents and antioxidant activities

		Karotenoid	FRAP	ABTS	DPPH
Karotenoid	Pearson Correlation	1	-.078	-.219	.027
	Sig. (1-tailed)		.421	.286	.473
	N	9	9	9	9
FRAP	Pearson Correlation	-.078	1	.874**	.601*
	Sig. (1-tailed)	.421	9	.001	.043
	N	9		9	9
ABTS	Pearson Correlation	-.219	.874**	1	.624*
	Sig. (1-tailed)	.286	.001		.036
	N	9	9	9	9
DPPH	Pearson Correlation	.027	.601*	.624*	
	Sig. (1-tailed)	.473	.043	.036	1
	N	9	9	9	9

**Correlation is significant at the 0.01 level (1-tailed)
*Correlation is significant at the 0.05 level (1-tailed)

with the value of r=0.874 and r=0.601, respectively. For ABTS and DPPH assay, there is a positive correlation with the value of r=0.624.

The results of this study were in line with a previous study conducted by Abu Bakar et al. (2009) which showed that the seed of *A. odoratissimus* has higher phytochemical contents and displayed higher antioxidant activity as compared to the flesh part.

CONCLUSION

In conclusion, the extracts of *A. odoratissimus*, *A. kemando* and *A. integer* have a potential to be used in nutraceutical industry due to high phytochemical contents especially in the peel and seed part of the fruits that contribute to high antioxidant activities.

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